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CIRCADIAN RHYTHM OF PHYSIOLOGICAL FUNCTIONS IN CLINOSTATIC HYPOKINESIA

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In the first 10 days of a strict bed regime (for medical reasons) changes were noted in the circadian rhythm of the heart rate, body temperature, minute volume of respiration and openness of the bronchial passages. By the 19-21st day in bed initial rhythms of the first three indices reappeared. Changes in the character of individual rhythm curves and correlations between rhythms of heart rate and body temperature were statistically significant while no significant differences were found for mean values of sinusoid amplitude and phase with which empirical curves of rhythms were approximated.

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Periodic changes in the state of the body throughout the day are attracting the attention of researchers. Studying circadian periodicity was one method of approaching evaluation of the aftereffects of an experimental bed regime in man. In these tests a number of changes was noted in circadian periodicity [5, 7, 8]. Fluctuations in various indices differed in phase — desynchronization was noted [1-3]. In the present study changes in circadian rhythm are examined when a bed regime was observed for medical reasons.

We studied 13 women and 10 men ranging in age from 12 to 64 years. For three weeks they were kept on a strict bed regime after undergoing diathermocoagulation of the sclera in connection with detachment of the retina. They spent the entire time lying on their backs without taking their heads or shoulders off the bed. Their eyes were covered with a thick binocular bandage. The local character of the surgical intervention made it possible to view changes in the condition of the subjects while they were in bed primarily

*Translator's Note: Numbers in margin indicate pagination of original foreign text.

as changes caused by prolonged hypokinesia and, perhaps, also by lack of sight. When they got out of bed at the end of the period, all subjects experienced more or less pronounced orthostatic inadequacy — faster heart rate and reduced arterial pressure, often accompanied by weakness and dizzyness, relieved by changing to a horizontal position. These shifts were previously described after an experimental bed regime in healthy persons [4, 14].

METHOD

In the subjects we studied: heart rate on the electrocardiogram, body temperature in the armpits measured by a maximum thermometer, minute volume of respiration and bronchial passages using a universal pneumotachygraph [9]. The last two indices were measured in only 12 subjects.

All measurements were made at 10 p.m., 4, 8 and 11 a.m., 2, 6 and 10 p.m. /1146 and 4 a.m. The first and last measurements were not considered in calculations. These series of measurements were made 4 times — 2-3 days before and 2-3, 9-10 and 19-21 days after surgical intervention.

RESULTS OF STUDY

Fig. 1 gives averaged empirical curves of circadian rhythm. In the first 2-3 days after surgery the level of the body temperature curve increased evenly, curves of the heart rate and bronchial passages were slightly flattened and the curve of minute volume of respiration even showed a tendency toward distortion. Later initial rhythms of body temperature and heart rate were restored. Changes in minute volume of respiration were still noted on the 9-10th day but the rhythm of the bronchial passages remained altered until the end of observations. We could find no indications in available literature that circadian rhythm of bronchial passages had ever before been described by anyone.

Because of the small number of observations for both respiratory indices we were limited only to asserting the presence of periodic circadian fluctua-

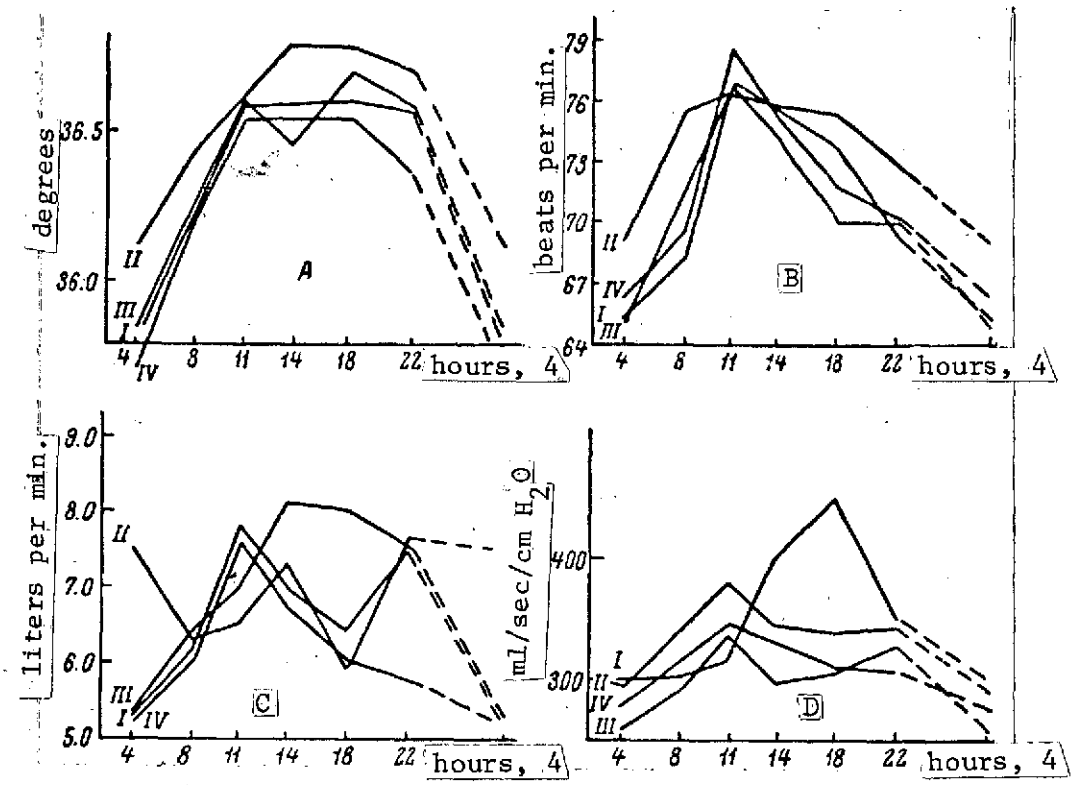

Figure 1. Averaged curves of circadian rhythm of subjects.

A — body temperature, B — heart rate, C — left — minute volume of respiration, D — openness of bronchial passages. I — initial condition, II — 2-3rd day, III — 9-10th day, IV — 19-21st day in bed.

tions ($p<0.01$).

For heart rate and body temperature, the significance of differences between measurements after various lengths of time in bed was also evaluated.

Figure 2 gives results of calculations by the cosine-analysis method [13]. Circadian periodic fluctuations are approximated by a sinusoid formula. Data for different series of measurements are expressed by mean sinusoid parameters — its amplitudes and phases — characterized by a vector in a system of polar coordinates. The length of the vector corresponds to amplitude and the direc-

tion to phase. Confidence limits for the end of the vector in the measurements taken for a 95% level of significance form an ellipse of errors. The ellipses intersect each other and, therefore, the difference between series is insignificant.

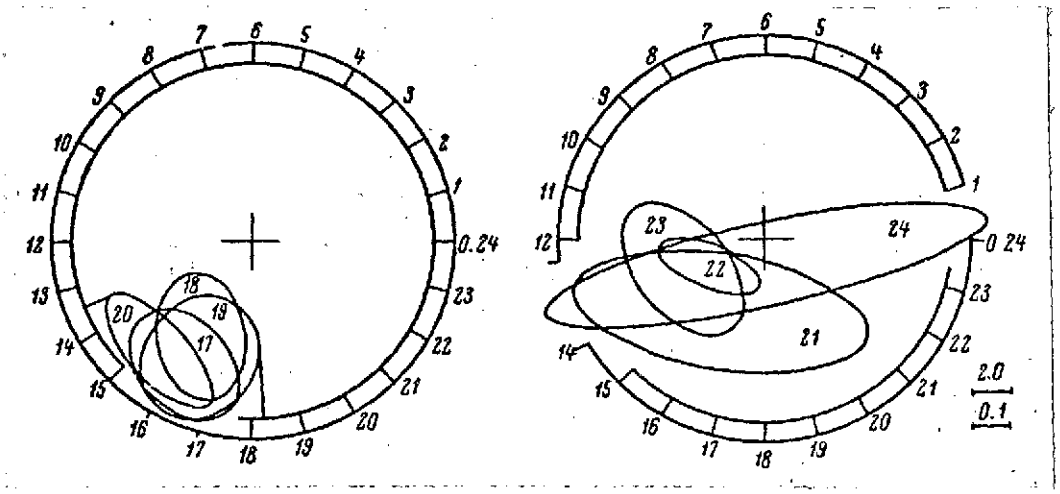

Figure 2. Ellipses of errors characterizing confidence limits for mean indices of circadian rhythm.

Left — body temperature, right — heart rate: 17 and 21 initial condition; 18 and 22 — 2-3rd day; 19 and 23 — 19-21st day; 20 and 24 — 19-21st day. Other explanations in text.

Individual rhythm curves were evaluated by methods described in the literature [10, 12]. On the 2-3rd and 9-10th days the number of altered (in comparison with normal) curves of heart rhythm and on the 9-10th day the number of altered curves of body temperature were statistically much greater than in the initial state ($p<0.05$). By the 19-21st days the number of altered curves becomes close to the initial level (Table 1).

Pair correlation coefficients are calculated for rhythms of body temperature in accordance with recommendations of [2, 3]. In the initial condition the closeness between these two indices was not high, but significant. On the 2-3rd and 9-10th days correlation coefficients were reduced below 95%

TABLE 1

NUMBER OF ALTERED CURVES OF CIRCADIAN RHYTHM IN SUBJECTS

Days of observation	Total rhythm curves	Including altered curves			
		Body temperature		heart rate	
		number	%	number	%
Initial condition	23	10	43.5	5	21.7
On 2-3rd day	23	10	43.5	11	47.8
On 9-10th day	23	15	65.3	8	34.7
On 19-21st day	23	7	30.4	7	26.1

level of significance and on the 19-21st day the initial closeness of correlation was again restored (Table 2).

Thus, individual evaluation of the shape of rhythm curves and calculation of the closeness of correlation between test indices detect significant differences where no such significance was found in approximation of sinusoid rhythms.

DISCUSSION OF RESULTS /1148

The circadian rhythm of bronchial passages with a minimum in nighttime hours found in these studies evidently reflects periodic fluctuations in lack of obstruction in the bronchi because of periodic fluctuations in the tone of the vagus nerve. These fluctuations were noted in persons with healthy lungs but are of undoubted interest also for comparison with the predominant occurrence in lung patients of bronchial asthma attacks at night. Evidently, circadian periodicity of bronchial passages and its disturbance can be important in the pathogenesis of attacks of dyspnea during bronchial asthma.

Changes in circadian rhythm on the 2-3rd and 9-10th days in bed are, evidently, reactions of the body to an unusual situation with lack of move-

ment and can also be the result of the surgical intervention. The similarity of these shifts with those described in an experimental bed regime [7, 8] suggests that the necessity for reduced motor activity is also of basic importance in the present studies. Sharp reduction in motor activity changes afferent stimulation from proprioceptors and reflexively changes the course of circadian rhythm. These influences can be called motor-visceral in accordance with the formulation of M. R. Mogendovich [6]. Restoration of initial rhythm by the 19-21st day shows that in the second half of the test period there was some degree or other of adaptation to conditions of limited motor activity and adjustment of regulation of circadian rhythm.

TABLE 2

CORRELATION BETWEEN BODY TEMPERATURE AND HEART RATE IN DIFFERENT SERIES OF MEASUREMENTS

Day of observation	Correlation coefficient
Initial condition	0.36
On 2-3rd day	0.20
On 9-10th day	0.24
On 19-21st day	0.38
Critical value with 95% level of significance	0.25

Significant differences in the character of individual curves of rhythm and in the closeness of correlations between rhythms in individuals in the absence of such differences for averaged indices in cosine analysis can be due to the fact that bed regime has a greater effect on static distribution of the course of rhythms in individuals and less effect on averaged characteristics of the group. It is also possible that changes developing in the shape of the rhythm curve are detected earlier than in sinusoid amplitude and phase with which empirical curves of rhythm are approximated in cosine analysis. In recent years there have been indications that the shape of the rhythm curve can, in a number of cases, be of great physiological interest [2, 3, 15].

CONCLUSIONS

1. Staying in bed for three weeks first changes circadian rhythm in subjects, but by the end of the period the original rhythm is restored.

2. In the persons examined we found circadian rhythm of bronchial passages, i.e., periodic fluctuations in bronchial passages with minimum noted at night.

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